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WESTERN SPRUCE BUDWORM EGG MASS-DEFOLIATION SURVEYS--A WORKING GROUP PROGRESS REPORT

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INTRODUCTION

The western spruce budworm, Choristoneura occidentalis Freeman, is a serious pest in the western United States, defoliating millions of acres of spruce-fir forests (Johnson and Denton, 1975; McKnight, 1968). For many years, forest entomologists have been sampling budworm egg masses to monitor population trends, forecast defoliation or to evaluate the effects of direct control.

Sampling procedures have been developed for budworm in Oregon (Carolin and Coulter, 1972) and a sequential sampling technique in Colorado (McKnight, et. al., 1970). Most recent sampling has been done using essentially one of these two methods, although local modifications have been made in both sampling schemes. In the five western Regions of the U.S. Forest Service where western spruce budworm is a pest, no two were using exactly the same method. Furthermore, the most extensive budworm infestations currently are in Montana and Idaho (Anonymous, 1976) and Washington. It is not known how well models developed in Oregon and Colorado fit these different Regional situations.

Dissatisfaction with the results of egg mass surveys and defoliation forecasts prompted western forest entomologists to form a working group to improve sampling techniques and standardize methods. Members of this group are: Wayne Bousfield (R-1); Charles Minnemeyer (R-2); Robert Acciavatti (R-3); Larry Stipe (R-4); Robert Dolph (R-6); David Fellin, Intermountain Forest and Range Experiment Station; David Grimble, and Robert Young, FI&DM/MAG.

This report describes progress and accomplishments of the working group in 1976.

OBJECTIVES

Objectives of this working group are to:

1. Evaluate the reliability of egg mass - defoliation models available for western Regions and adapt them, where necessary, to different Regional situations.
2. Standardize procedures west-wide for egg mass sampling, description of defoliation and reporting of the results of egg mass and defoliation surveys.
3. Have reliable, defensible prediction models available for western spruce budworm egg mass surveys by 1978.

The working group will be disbanded when these objectives have been met, probably in 1978.

SURVEY DESIGN

The following approach was agreed to for estimating egg-mass numbers and describing defoliation for the 1976 field season:

I. Location

Field work was done in Regions 1, 2, 3, 4 and 6. Regional personnel established plots and collected field data from infested areas, primarily on National Forest land. MAG personnel assisted in planning, data analysis and coordination of the effort between Regions.

II. Egg Mass Sampling

1. Entomological Unit - The smallest unit for which a defoliation forecast was made was an entomological unit. The acreages and locations of entomological units were determined by the Regions. They were geographical areas of variable size, but of uniformly susceptible host type. Entomological units were intended to be distinct areas which would be managed for insect control as a block; i.e., a spray block in a control project.

2. Host Species - For the present, Douglas-fir was the host species sampled. In mixed stands, Douglas-fir was preferred over other species.

3. Clusters - The sampling unit was a cluster plot of 3 trees. Clusters were distributed randomly to represent all portions of the entomological unit sampled. Clusters were referenced by sketch maps to a known point for relocation. The number of clusters located in each entomological unit was variable, depending upon the size of the unit sampled; however, 10 clusters were planned per unit in 1976.

4. Trees - Three trees were sampled in each cluster. Selected trees were open grown Douglas-fir in the 30-60 feet height range and were numbered with paint for relocation. Some defoliation was evident on selected trees but none were totally defoliated or had dead tops.

5. Branches - Two tip branches (approximately 30 inches long) were removed with a pole pruner from opposite sides of the midcrown of each tree. Branches were measured and clipped to a length of 70 cm in the field. Maximum width (cm) of the branches was also measured in the field and the data were entered at that time on the data form. Branches were placed in individual bags, numbered for identification, and transported to the laboratory for examination at the earliest opportunity. Branches were kept cool until examination for egg masses.

6. Laboratory - In the laboratory, branch samples were examined to locate new egg masses. The number of new egg masses was entered on the data form (Fig. 1). In some cases, long-wave-length ultraviolet lights were used to aid in detection of new egg masses on foliage (Acciavatti and Jennings, 1976).

WESTERN SPRUCE BUDWORM EGG MASS SURVEY DATA FORM

Year _____ (1-2) T. ____ R. _____ S. _____ Date _____ Crew Name: _____

Region _____ (3 -4) Forest _____ (5 -7) Host _____ (8 -9) Unit _____ (10 -11) Cluster _____ (12 -13)

Survey Type _____ (14) Opt. 1 _____ (15 -) Opt. 2 _____ (20)

Tree	Branch	* Length (cm)	* Width (cm)	** Area (M^2) x.xxx	NEW EGG MASSES Number	No. 1/ Rows	Row 1/ Length (mm)	Un- 1/ hatched Eggs	Optional Use	
(21) 1	1	(22-24)	(25-27)	(28-32)	(33 - 35)	(36-38)	(39-41)	(42)	(43-)	(50)
	2	(51-53)	(54-56)	(57-61)	(62 - 64)	(65-67)	(68-70)	(71)	(72-)	(79)
(21) 2	1	(22-24)	(25-27)	(28-32)	(33 - 35)	(36-38)	(39-41)	(42)	(43-)	(50)
	2	(51 53)	(54 56)	(57 61)	(62 64)	(65 67)	(68 70)	(71)	(72-)	(79)
(21) 3	1	(22-24)	(25-27)	(28-32)	(33 - 35)	(36-38)	(39-41)	(42)	(43-)	(50)
	2	(51-53)	(54-56)	(57-61)	(62 - 64)	(65-67)	(68-70)	(71)	(72-)	(79)

Cluster Average

Egg Mass/m^2: _____

Egg mass/m^2 = $\left[\sum_{\text{Tree}}^{3} \sum_{\text{Branch}}^{2} \left(\frac{\text{egg mass/branch}}{m^2/\text{branch}}\right)\right] / 6$

1/ Data to be taken on 1 egg mass/branch

* Length, width - completed in field by branch management.

** Area - completed in lab by grid method, record to 3 decimals.

Figure 1. - Data form for egg mass surveys of the western spruce budworm.

In addition, the length (mm) and the number of rows of eggs was entered on the data form for 1 egg mass per branch. An estimate of the percent unhatched eggs in that same egg mass will be recorded in 1977, according to the following system:

Percent Unhatched	Code
0 - 25%	1
25 - 50%	2
50 - 75%	3
75 - 100%	4

Branch foliage area will also be estimated in the laboratory in 1977 by clipping branches into segments and arranging the segments over a grid paper. Total area will then be estimated directly from the grid coverage and recorded on the data form. Comparison at a later date of area estimates by the two methods (field measurements of length-times-width versus laboratory grid paper) will enable selection of the most consistent and accurate method for future use.

7. Sampling Precision - Based on previous information about egg mass sample variability, it was agreed that an acceptable level of precision at the entomological unit level would be a standard error of 20 percent, 9 out of 10 times.

8. Data Form - An egg mass survey field data form (Fig. 1) was designed for accurate data collection and easy transfer of the data to computer cards or tape. One form accommodates all data from one 3-tree sample cluster.

III. Description of Defoliation

Defoliation will be estimated in the field during 1977 on the same marked 3-tree clusters where egg masses were sampled in 1976, and at the same time that a new egg mass sample is taken.

1. Branches - Four branches will be removed with pole pruners from the midcrown of each marked sample tree. Branches should be taken from opposing quadrants of the crown. Since 2 of these branches may be used as new egg mass sample branches after current defoliation has been estimated, they must be at least 70 cm in length.

2. New Shoots - Defoliation will be estimated from the first (from the tip) 25 current shoots on each branch. Shoots should be considered from alternate sides of branches; i.e., 25 from left side of the first branch, then 25 shoots from the right side of next branch. Branches which will not be used as an egg mass sample may be most conveniently evaluated by actually removing the shoots from the branch and placing them in an array on a ground cloth.

3. Shoot Rating - Each of the 25 shoots per branch will be evaluated individually and rated 1, 2, 3 or 4 to indicate the degree of defoliation according to the following system:

Percent Defoliation	Rating
0 - 25	1
25 - 50	2
50 - 75	3
75 - 100	4

Hand tally counters will be used to maintain a cumulative rating tally as each of the 25 shoots are examined in turn. For example, if the first shoot is about 40 percent defoliated, the tally counter will be punched twice, if the next is about 60 percent consumed the counter will be punched 3 more times, and so on until all 25 shoots have been examined. The cumulative total of ratings for each branch will be a direct percentage defoliation estimate for the branch.

4. Data Form - The defoliation survey data form (Fig. 2) will accommodate all defoliation estimates from a 3-tree cluster. Identification data, at the top of the form, is identical to the previous egg mass sampling data forms.

Total defoliation ratings are entered directly for each branch and the sum for all branches per tree divided by 4 to get a tree average. Ratings for the 3 trees in a cluster are then averaged to get a cluster average. The cluster average is reduced by 12.5, which will convert the estimate to the midpoint of the defoliation class, and reported as percent defoliation for the 3-tree cluster.

IV. Data Analysis

Data gathered by the working group will be combined and analyzed through facilities at the Fort Collins Computer Center (FCCC). Regression models for egg mass density-defoliation will be generated for each entomological unit sampled and for each Forest. Models will be evaluated to determine whether or not the same model(s) will predict defoliation within Regions or west-wide.

Regional personnel will be responsible for editing, coding, and punching data prior to entering into the FCCC system. Summary tables will be produced for decision-making purposes by Regional personnel as soon as their data is entered into the system. Detailed instructions for coding and editing of data, with examples of expected summary tables, have been provided to Regional personnel.

V. Regression Analysis

The egg mass/defoliation relationships will be used to improve existing prediction models. The models under consideration are linear,

WESTERN SPRUCE BUDWORM DEFOLIATION SURVEY DATA FORM

Year _____ (1-2) T. ____ R. _____ S. _____ Date _____ Crew Name: _____

Region _____ (3-4) Forest _____ (5-7) Host _____ (8-9) Unit _____ (10-11) Cluster _____ (12-13)

Survey Type _____ (14) Opt. 1 _____ (15-) Opt. 2 _____ ( ) Opt. 3 _____ (20)

Tree	Branch	Defoliation 1/	Tree Average 2/	Comments
(21) 1	1	(22-24)		
	2	(25-27)		
	3	(28-30)		
	4	(31-33)		
(34) 2	1	(35-37)		
	2	(38-40)		
	3	(41-43)		
	4	(44-46)		
(47) 3	1	(48-50)		
	2	(51-53)		
	3	(54-56)		
	4	(57-59)		

Total: _____

1/ Defoliation = Total of ratings from 25 shoots per branch.

2/ Tree Average = $\frac{\Sigma \text{ Defoliation}}{4}$

Average percent defoliation (cluster)

= $\frac{\Sigma \text{ tree average}}{3}$ - 12.5 = _____ %

Figure 2. Field data form for defolation surveys of the western spruce budworm.

quadratic and other linearized forms by transformations. The independent variable (X) is egg-mass and the dependent variable (Y) is defoliation.

In standard linear regression three basic assumptions are made about the relationship of Y and X:

1. For each selected X there is a normal distribution of Y from which the sample value of Y is drawn at random.
2. The population of values of Y corresponding to a selected X has a mean μ that lies on a straight line. $\mu = \alpha + \beta (X - \overline{X}) = \alpha + \beta X$.
3. In each population the standard deviation of Y about its mean, $\alpha + \beta X$ has the same value.

The mathematical model is specified by $Y = \alpha + \beta X + \mathcal{E}$ where $\mathcal{E}$ is the random error term (Snedecor and Cochran, 1967).

Two considerations need to be addressed with the applications of the egg mass and defoliation variables:

1. Independent samples are drawn from which the X and Y values are determined.
2. The values of each X and Y are cluster level means based on 6 and 12 samples, respectively. A subsampling scheme is used by averaging branches to trees and the three trees to the cluster.

The first consideration causes no great concern since, if we draw a second sample, the values of X could in part be different, but the corresponding Y values will still meet the three basic assumptions.

The second situation poses a little more serious problem. The values for both the X and Y variables contain a sampling error component due to subsampling branches and trees. A basic assumption in linear regression is the X is fixed and free of measurement and/or sampling error. In many applications this is not reasonable and is often violated. The biases are thought to be negligible if the sampling errors do not exceed 10 percent. Usually this occurs when the sample size for each observation is relatively large and/or the data is clustered such that the variation is small.

The use of regression analysis must be done keeping in mind the basic assumptions, and those not being satisfied should be evaluated for the degree of bias. During the course of the egg mass defoliation study, the effects of bias in regression estimators will be examined.

VI. Reporting

Regional egg mass data and defoliation forecasts will be reported as usual by Regional offices.

Periodic progress reports on task force activities will be prepared by FI&DM, MAG staff for distribution to all interested parties.

PROGRESS

In August 1976, egg mass sampling data were collected in a total of 57 entomological units in the five western Regions. Additional blocks were sampled in R-2 and R-6 using slightly different methods and these data are not included here. In R-4, many of the sample trees were grand fir; these data are included but will not be combined with data collected from Douglas-fir. Corresponding defoliation estimates will be collected in 1977 from the same sample trees in each Region, at the same time that another egg mass sample is taken.

I. 1976 Egg Mass Sampling Results

Statistics calculated for each entomological unit sampled (Tables 1-4) include:

1. Sample means ($\bar{x}$) - average number of new egg masses per M^2 foliage.
2. Standard error (SE) of the sample means.
3. Relative standard error - the standard error expressed as a percent of the sample mean.
4. Optimum sample size (n) - an estimate of the number of samples which would have been necessary in each unit to obtain the stated precision goal of a relative standard error of 20 percent.

In 1976, we planned to take at least 10 samples in each entomological unit sampled. More samples were to be taken in very large blocks. Subsequent examination of the data showed that in more than half of the units sampled, the number of samples taken was not adequate to realize a sampling error within the desired limits (Tables 1-4). In some cases, where population densities were low, sample variances were so large that it would have been impracticable to take sufficient numbers of samples. Calculation of optimum sample size, after grouping the data by budworm intensity in each Region (Table 5), indicated that a sample size of 20 would have been adequate in about three-fourths of the entomological units. Consequently, sample size will be increased for the 1977 season to a minimum of 20 samples per block; more, when the entomological unit is unusually large.

Egg mass densities ranged from low (less than one egg mass per square meter of foliage) to very high. Most low populations sampled were newly discovered infestations where no control was currently being considered. Forecasts of defoliation in 1977 from these estimates of egg mass density were made by Regional personnel by usual methods with established models.

II. Data Management System

Specifications for a data storage and analysis system have been developed and submitted to Regional personnel for review. Included were instructions for coding and editing data, examples of output summary tables expected from the system, and examples of prediction models to be developed (Appendix 1). Detailed specifications for data analysis are available upon request to interested parties.

Table 1. Summary of 1976 western spruce budworm egg mass sampling in R-1.

Entomological Unit	Acres 1/	Number of Clusters Samples (n)	Mean Egg Masses per M^2 Foliage	Range	Standard Error	Standard Error as percent of mean	Samples Needed to get SE within 20% of mean
Flathead IR	111,000	9	24.1	2.3-46.1	4.5	19	9
Flathead NF	211,000	8	2.3	0-7.7	0.9	41	35
Lewis & Clark NF	55,000	5	41.6	16.7-82.7	12.4	30	12
Helena NF							
West	381,000	13	38.5	7.3-72.5	5.4	14	7
South	326,000	8	46.7	1.5-202.7	23.8	51	52
Canyon Ferry	350,000	12	28.7	0-172.8	13.7	48	69
Townsend	307,000	10	25.5	6.3-69.4	5.4	21	12
Idaho Panhandle NF	563,000	15	15.3	0.7-36.7	2.7	17	12
Bitterroot NF							
West	798,000	11	39.9	0-69.2	8.1	20	11
East	566,000	9	23.0	1.7-49.1	5.0	22	11
Gallatin NF							
Bridger	309,000	17	62.6	0-111.7	7.3	12	6
Gallatin Canyon	211,000	19	41.9	1.6-105	6.3	15	11
Yellowstone Valley	396,000	11	42.6	6.7-95.4	9.0	21	13
Nezperce NF	188,000	9	4.5	0-9.7	1.1	23	12
Kootenai NF	36,000	3	14.4	7.4-23.8	4.9	34	9
Clearwater NF							
Pierce	383,000	19	9.1	0-33.1	2.5	28	37
Kelly Creek	566,000	7	7.7	4-12.8	1.3	17	6
Lochsa	628,000	11	7.4	0-17.3	2.2	30	25

Table 1. (Cont.) Summary of 1976 western spruce budworm egg mass sampling in R-1.

Entomological Unit	Acres 1/	Number of Clusters Samples (n)	Mean Egg Masses per M^2 Foliage	Range	Standard Error	Standard Error as percent of mean	Samples Needed to get SE within 20% of mean
Deerlodge NF							
Whitehall	321,000	16	30.3	0-119.8	8.0	26	29
Boulder	325,000	11	33.3	5-108.7	8.4	25	18
Flint Creek	390,000	6	16.2	0-34.2	5.4	33	17
Beaverhead NF							
Pioneer	225,000	3	26.0	7.4-43.5	10.4	40	12
Tobacco Root Mountain	481,000	12	16.9	0-57.7	5.5	33	32
Ruby	540,000	9	33.1	0-96.3	12.7	38	33
Madison	804,000	10	26.3	2.1-81.3	8.3	31	33
Lolo NF							
East	463,000	4	28.3	5.1-56.3	12.5	44	20
Clark Fork S	600,000	13	40.0	11.6-133.1	9.4	23	18
Clark Fork N	432,000	9	38.5	22.1-62.6	4.6	12	5
St. Regis	326,000	8	45.5	21.3-89.9	9.5	21	9
Total: 29 Units	11,292,000	297					

1/ Gross acreage; includes much non-host type land.

Table 2 Summary of 1976 western spruce budworm egg mass sampling in R-3.

Entomological Unit	Acres	Number of Clusters Samples (n)	Mean Egg Masses per M^2 Foliage	Range	Standard Error	Standard Error as percent of mean	Samples Needed to get SE within 20% of mean
Cibola NF							
Manzano	20,000	12	17.8	0.9-69.2	5.8	33	33
Sandia	11,000	10	15.1	0.5-37.8	4.1	27	19
Sante Fe NF							
Jemez West	100,000	11	12.3	0-47.5	3.8	31	27
Jemez East	100,000	10	16.5	4.3-33.1	3.0	18	9
Gila NF	40,000	10	9.6	1.4-14.4	1.5	15	6
Carson NF	75,000	10	38.2	12.6-57.5	5.1	13	5
Kaibab NF	100,000	10	17.3	1.1-55.0	6.1	35	32
Total: 7 Units	446,000	73					

Table 3. Summary of 1976 western spruce budworm egg mass sampling in R-4.

Entomological Unit	Acres	Number of Clusters Samples (n)	Mean Egg Masses per M^2 Foliage	Range	Standard Error	Standard Error as percent of mean	Samples Needed to get SE within 20% of mean
Boise NF							
GF	27,100	25	7.5	0-20.3	1.4	19	23
DF		1		0.0			
Salmon NF							
DF	430,000	19	1.2	0-6.9	0.4	38	67
Bridger-Teton NF							
DF	555,000	29	34.3	0.8-75.9	3.8	11	9
Targhee NF							
Henry's Lake DF	115,000	26	6.1	0-64.5	2.7	43	122
Pleasant Valley DF	154,000	26	25.6	0-90.3	5.9	23	34
Paynette NF							
Krassel DF	104,000	14	3.4	0-10.1	0.9	28	27
GF		5	7.2	0-24.8	4.5	62	49
Council DF	79,650	9	1.0	0-3.8	0.4	41	37
GF		33	3.2	0-10.5	0.5	17	24
East McCall DF	106,150	10	4.1	0.7-10.7	1.0	24	15
GF		24	7.6	0-36.1	1.6	21	27
West McCall DF	49,000	5	4.2	0-17.8	- -	- -	
GF		20	7.3	0-18.8	1.3	17	15
Price Valley DF	84,750	3	1.9	0-3.9	- -	- -	
GF		36	5.7	0-19.5	1.0	17	27
Total: 10 Units	1,704,650	285					

Table 4 Summary of 1976 western spruce budworm egg mass sampling in R-6.

Entomological Unit	Acres	Number of Clusters Samples (n)	Mean Egg Masses per M^2 Foliage	Range	Standard Error	Standard Error as percent of mean	Samples Needed to get SE within 20% of mean
Yakima IR	3,000	28	0.4	0-3.4	0.1	40	106
Warm Springs IR	3,800	17	6.2	0.7-22.9	1.3	21	19
Colville IR	2,100	34	0.9	0-7.3	0.3	32	86
Okanogan NF (Tonasket RD)	120	11	0.3	0-1.8	0.2	56	82
Mt. Hood NF (Bear Springs RD)	2,000	8	0.5	0-2.1	0.3	54	58
Total: 5 Units	11,020	98					

Table 5. Western spruce budworm egg mass sampling data grouped within Regions by ranges of egg mass density.

Region	Ranges of Egg Densities (Mean Egg Masses/ M^2 Foliage)	Number Entomological Units	Number of Samples (n)	Mean Egg Masses/ M^2 Foliage	Standard Error of Mean	Standard Deviation	Variance	Optimum Sample Size (n)
1	0-4	2	17	3.484	.744	3.069	9.419	20
	5-20	7	73	12.074	1.411	12.056	145.348	25
	> 20	20	206	35.793	1.911	27.422	751.980	15
	All	29	296	28.088	1.536	26.426	698.349	22
3	All	7	73	18.192	1.916	16.369	267.949	20
4	Douglas-fir							
	0-4	8	86	2.784	.490	4.548	20.680	67
	> 20	2	55	30.191	3.445	25.547	652.662	20
	All	10	141	13.846	1.800	21.444	459.847	60
4	Grand fir							
	All	6	143	6.024	.527	6.298	39.666	25
6	< 1	6	90	.538	.124	1.177	1.385	120
	> 4	1	23	4.222	1.025	4.915	24.154	34
	All	7	113	1.288	.267	2.840	8.065	100

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APPENDIX

WESTERN SPRUCE BUDWORM EGG MASS - DEFOLIATION SURVEYS

Instructions for Coding and Editing Data

I. Coding Identification: Egg Mass Survey Data Form; Defoliation Survey Data Form.

Year	- (1-2)	Enter last 2 digits of current year.
Region	- (3-4)	Enter 2 digit number to indicate Region.
Forest	- (5-7)	Enter standard 3 digit number for specific National Forest.
Host	- (8-9)	Enter 01 for Douglas-fir. (P. menziesii). 02 for Grand fir. (A. grandis). 03 for White fir. (A. concolor). 04 for Subalpine fir (A. lasiocarpa).
Unit	- (10-11)	Enter 2 digit number to indicate entomological unit (block) sampled.
Cluster	- (12-13)	Enter 2 digit number to indicate cluster (plot) sampled.
Survey Type	- (14)	Enter 1 for Egg Mass Survey. Enter 2 for Defoliation Survey.

Option 1 - For additional data as required by Regions.
Option 2
Option 3 - (Defoliation Survey Data form only)

Coding Data

Egg Mass Survey Data Form:

Tree - (21) Enter 1 digit number for tree in cluster.

Branch Length - (22-24) (51-53) Enter 3 digit number for length in centimeters of sample branch.

Branch Width - (25-27) (54-56) Enter 3 digit number for width in centimeters of sample branch.

Branch Area - (28-32) (57-61) Enter 5 digit number for area in square meters of sample branch, record to 3 decimals.

New Egg Masses

Number - (33-35) (62-64) Enter 3 digit number for total current year egg masses per branch.

Number of Rows - (36-38) (65-67) Enter 3 digit number for number of rows of eggs in one egg mass per branch.

Row Length - (39-41) (68-70) Enter 3 digit number for length in millimeters of one egg mass per banch.

Unhatched Eggs - (42) (71) Enter 1 digit code for estimate of percent unhatched eggs in one egg mass per branch, either parasitized or non-viable.

Code	Percent Unhatched
1	0-25%
2	25-50%
3	50-75%
4	75-100%

Optional Use - (43-50) (72-79) For additional data as required by Regions.

Defoliation Survey Data Form:

Tree - (21) (34) (47) Enter 1 digit number for tree in cluster.

Defoliation - (22-24) (25-27) (28-30) (31-33) (35-37) (38-40) (41-43) (44-46) (48-50) (51-53) (54-56) (57-59) Enter 3 digit number for total cumulative defoliation rating per branch.

Optional Use - (60-80) For additional data as required by Regions.

II. Editing Data Forms

All field-collected data will be entered on both forms in pencil.

All laboratory data (i.e., egg mass numbers, length, and width) will be entered on forms in blue pencil.

All field and laboratory data must be edited for accuracy and completeness. Corrections and verifications (i.e., atypical data) will be made in red pencil on data forms.

A raw data listing will be generated from the computer to be used for a final check on the data. Changes can be made in the raw data at this time prior to summary.

Egg Mass Survey Data Form: Branch length and width are measured in the field; branch area column must be completed in the laboratory by the grid method.

III. Output Specifications

Level of output - For each entomological unit sampled, a Table 1 and 2 will be generated showing cluster (plot) averages and standard errors. Correlations and prediction models will be produced, as in Table 3.

Western spruce budworm egg mass-defoliation survey

Table 1. EGG MASS SAMPLING RESULTS

Year _____ Region _____ Forest _____ Unit _____

Host _____ Number of Samples _____

Cluster (Plot)	$\bar{X}$ Branch Area (M^2)	$\bar{X}$ Egg Masses Per Branch	$\bar{X}$ Rows Per Egg Mass	$\bar{X}$ Length Per Mass (mm)	Opt. 1	Opt. 2	Opt. 3
01							
02							
03							
04							
05							
06							
07							
08							
09							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
Mean							
Standard Error							
Relative SE (%)							
Optimum Sample Size for 20% SE							

Western spruce budworm egg mass-defoliation survey

Table 2. DEFOLIATION SURVEY RESULTS

Year _____ Region _____ Forest _____ Unit _____

Host _____ Number of Samples _____

Cluster (Plot)	Average Percent Defoliation			Average	Adjusted Average
	Tree 1	Tree 2	Tree 3		
01	xx.x	xx.x			
02	xx.x	xx.x			
03	xx.x				
04					
05					
06					
07					
08					
09					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
Mean	xx.x				
Stand Error	xx.x				
Relative SE (%)	xx.x				

Western spruce budworm egg mass-defoliation survey

Table 3. Correlations and Prediction Models

YEAR	REGION	FOREST	UNIT	HOST	Number of Samples N	Egg Mass (x) versus Defoliation (Y) Correlation R	Prediction Model Form	A	B	C	D	R^2	Standard Error of Estimate

NOTE: A. The form of the equation could be (1) Linear $Y = A + B\ x$

(2) Quadratic $Y = A + B\ x + C\ x^2$

(3) Loqarithmic $Y = A + B$ LOG (x), or others

B. A zero in the Identification field indicates data has been aggregated to a "combined" Level; i.e., all years in a unit, all units in a forest, all forests in the Region, or any combination for which data can be statistically combined.